SOME ENVIRONMENTAL RELATIONS OF THE BIRDS IN THE MISSOURI RIVER REGION

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Over two hundred days were spent between 1921 and 1925 in an intensive survey of the land vertebrates of a small area of ground adjacent to the Missouri River in Doniphan County, Kansas. The center of the area is the townsite of Geary City at the point where a creek called Brush Creek enters the floodplain of the Missouri River. This paper is a summary of the more general environmental relations of the birds observed there. All statements made here are based on observations which were made within one and one-half miles of the center of the area.

The object of this work was to study the relations of the vertebrates to their environment and especially to gather data that would show as nearly as possible: what species of land vertebrates were present within the area; the frequency of occurrence and the relative abundance of those species; the local or habitat distribution of each of those species; the factors which determine the presence and habitat distribution of each species; the annual cycle of activity of each species in this area; a way to analyze vertebrate associations and successions.

The location for work was selected on the Missouri River because: little was known of the vertebrate fauna of that part of Kansas; a great variety in habitat conditions was present due to the influence of the river; rapid changes in the habitat and the vertebrate life could be studied.

Topography

About one-half the area included within this study consists of the Missouri River and its floodplain on the Kansas side. The remainder is made up of the bluffs which face the river and which are broken by the valley of Brush Creek, and a small part of the high land back of them. The riverside elevation at this point is close to 800 feet and the bluffs rise above this from 150 to 200 feet. They are of loess and limestone and are capped with loess. One part of the bluff contains some glacial drift material. There are several shelves on the bluff which mark former levels in the cutting of the river. These shelves are nearly level with steep slopes above and below them. The bluffs face the east and a little to the south. The creek flows in a deep valley that runs, in general, from the northwest to the southeast. In many places it has rather low banks on one side and high, nearly vertical cuts of loess on the opposite side. Back of the bluffs the topography is more rolling.

The Habitat

River. The Missouri River at this point may be said to have reached a stage of late maturity in the cycle of erosion. There is still a considerable amount of current but the valley has been eroded to a width sufficient to make room for meanders from bluff to bluff. During the winter the Missouri River at this point is important to birds chiefly as a feeding ground for a few of the aquatic species which migrate only as far south as they are forced by the frozen waters. During the spring the river furnishes a highway of travel for nearly all the species that migrate through the region. Some of those transients follow the water closely, some follow the shorelines and many of them follow the bluffs and the strip of bottomland bordering the river. In summer the river is used to some extent as a feeding ground for fish-eating birds, but its chief influence upon birds is indirect. This is its influence as an erosive agent in changing the extent and character of the land in the floodplain. During the fall the river again serves as a roadway for migrating birds. The birds appear to be dependent upon the river in much the same way as in spring except that they are not so hurried in their movements and they move down the river more slowly than they go north in the spring.

Creek. Brush Creek, a small stream which is usually dry during a part of the summer, flows across the area. The frequent, nearly vertical banks of loess material through which the creek has cut furnish suitable sites for nesting for several species of birds. The chief influence of the creek upon the bird-life of this vicinity lies in its work as an erosive agent. Since a large share of the land which the creek drains has been in cultivation a large amount of soil is carried away every summer during flood times. While most of this material is carried away by the river, some of it has contributed to the production of the Missouri River bottoms within the area of study. The deep creek valley also serves as a roadway for some birds both in their daily excursions to the uplands for food and in their migration flights.

Lake. Roundy Lake was formed by a shift in the course of the river which took place about twelve years before these studies were begun (1921). The course of the river was deflected by striking the bluff a short distance above this point so that it swung back to the east and left nearly 2500 acres of accretion to the Kansas bank. The lake was left in this newly made land. Brush Creek helped to fill in the lower end of the lake and later contributed largely to the decrease

Figure 1. Roundy Lake from the bluff on northwest side. Trees in foreground are on the bluff. Missouri River is shown in background. Photograph taken August, 1922.

Figure 2. Roundy Lake from east side. On opposite side of the lake at the left is shown a large patch of *Typha*. In the background is shown all the bluff included in this study and, in the center, the valley of Brush Creek as it enters the flood plain of the Missouri. Photograph taken June, 1922.

in depth and area of the water. In the summer of 1921 the water in the lake covered an area of nearly 200 acres. This area was constantly decreased until in the spring of 1925 less than forty acres of water surface remained. During the same period of time the depth was reduced from about four feet to less than two feet in the deepest place. In addition to deposits from overflow from the creek some material was left each season by the overflowing waters of the river, some was washed in from the adjacent bluffs, some dust was blown into the lake by the wind in dry times and when the ground was frozen in winter, and a great deal of organic matter was added by the invading vegetation which grew each summer and was added to the ooze of the bottom of the lake in the fall.

With an abundance of invertebrate and plant food, and being in a rather secluded location that was little disturbed by man, the lake furnished an excellent feeding ground for some summer resident birds, and an even better resting and feeding ground for several transient species.

Lake-shore. In the fall of 1921 the water in the lake was high and the edge was back in the vegetation so that there was no portion of the shore that might in any way be suitable for shore birds. Doniphan Lake, three miles away, had a broad mud-flat around the water's edge upon which several thousands of shore birds were feeding at that season. The next fall (1922) the water was low in Roundy Lake and was high in Doniphan Lake so that the mud-flat conditions were the reverse of those in 1921 and the flats at Roundy Lake were covered with feeding birds from early in August until late in September, while none were seen at Doniphan Lake. The mud-flats attracted a large number of species that would otherwise not have been found in the area. All of them stopped to feed and a few rested on the mud, but no species was found nesting on the shore and none sought protection there.

The finding of meadowlarks on the exposed mud-flats on two different occasions indicated a slight relationship of this division of the habitat to conditions of an open prairie.

Typha. Cattail (*Typha latifolia*) was the most important aquatic plant for the birds of this vicinity. It grew in large patches of several acres. These patches were nearly pure stands in and around the lake.

Slough. Several types of bodies of standing water on the flood-plain of the river may be classed under the name slough. All these are long, narrow and shallow depressions that are filled with water for a part or all of the year. On hot days in the summer many small

birds came to the springs and sloughs below them to drink and to bathe.

Salix-Populus. The name Salix-Populus was given to that division of the habitat in which willows and cottonwoods were the most important plants. Several species of willow grew in mixed and pure stands in various parts of the ground where these plants were dominant. This type of vegetation covered all the bottomland of the Missouri River except that which was covered with water and that which was in cultivation. Accompanying the rich growth of vegetation on this bottomland there was an abundance of insect life especially in late summer and in the fall when birds were preparing for migration and were moving south.

Creek-bottom. The creek-bottom included a narrow strip of land which bordered the creek in its course through the area to the point where it flowed into the floodplain of the river. Here the soil was rich and deep. There was usually sufficient moisture to insure a great amount of vegetation during each growing season. In seasons such as the summer of 1924, when there was an unusually large amount of flooding, the smaller plants and animals were covered with mud and they had little opportunity to grow. Black walnut, American elm, Kentucky coffee-tree, redbud, sycamore, and other trees found favorable conditions in the rich, deep soil along the creek and they grew to large sizes. The fact that there was no uniformity in the size of the various species of trees or in their spaciation indicated that the vegetation in this part of the habitat had reached a stage of climax.

Bluff. The timber on the bluffs covered nearly all the ground not in cultivation, within the area except that which was in the floodplains of the river and the creek. The vegetation on this part of the habitat was in a climax stage. The dominant trees were the various species of oak and hickory. In the spring and in the fall the timber on the bluff influences birds in much the same way as timber in other parts of the habitat except that there is a lesser attraction on the bluff than elsewhere for those birds which are usually found near the ground and which require a more dense ground cover than is present on most of the bluff. In winter there is less protection and less available food in the timber on the bluff except in the deeper ravines than in other types of timber and so this is the least used part of the woods at that season. Only small bands of birds which usually feed on the branches and trunks of trees were usually found on the bluff in winter. A few raptorial birds were found there throughout the year.

In summer the nesting facilities on the bluff are best suited to those birds which nest at some distance from the ground and in the branches of trees. A few nest on the ground and some nest in the cavities of the trees.

The bluff at this point has one peculiar relation to the daily activity of birds that was not noted in other parts of the habitat. That part of the bluff on which most of the work was done faces the east. In the morning the rising sun strikes the whole side of the bluff and it is quickly warmed so that insects become active and in turn the birds are active early after sunrise. In the afternoon shadows from the lowering sun fall over the bluff and it becomes cool sooner than the more level ground nearby so that activity of most birds as well as of other animals ceases earlier in the day on the bluff than on the more level portions of this area which receive sunlight until later in the day. In winter the activity ceases between three and four o'clock in the afternoon. In summer, activity stops on the bluff between five and six o'clock. It was also noted that activity ceases earlier in the afternoon on the lower part of the bluff than it does near the top where the warmth of the sun lasts for a longer time.

Timber-edge. Along the edge of the timber at the top of the bluff and around small timber patches there are narrow belts where conditions are partly like those of the timber and partly like those of open ground. Here are found small thickets of shrubs of various species and sometimes a dense growth of weeds and other herbaceous plants. Some kinds of birds, such as the flycatchers, were frequently found in the trees along the edge of the timber where there was an open ground on one side where they might make flights for insects. Several species seemed to prefer perches in the edge of the woods from which they sang or where they rested.

Sprouts. Whenever a field that had been cleared of timber was allowed to lie fallow for one or more years or was used as a pasture, sprouts immediately began growing from the roots of the trees that had been removed. Among these sprouts there was usually a dense growth of some weeds such as sweet clover (*Melilotus alba*) which with the sprouts often formed a dense tangle that was seven or eight feet high. The sprouts grew rapidly if they were left alone, but usually they were removed after two or three years and the ground was again put into cultivation. In all about forty acres of the ground in this area was growing up in sprouts while this work was being done. These fields of sprouts had the greatest influence in summer when several species of birds selected them as nest sites.

Figure 3. Roundy Lake from the bluff on the west side. In the foreground is a large patch of *Nelumbo lutea*. In the center of the lake is a first year's growth of *Typha*. At the left and in the background is shown the Salix-Populus stand on one of the older portions of the bar. Photograph taken July 18, 1923.

Figure 4. Roundy Lake in winter. In the foreground is a snow-covered patch of *Polygonum*. Back of that is a strip of*Nelumbo* in which are shown some muskrat houses. In the background is shown the bluff as it appears in winter. Photograph taken February 6, 1924.

Orchard. The three small apple orchards within the limits of this area included less than an acre of ground and less than one hundred trees. Most of the trees were old and had not been properly pruned for several years and they were not sprayed in the summer. The ground under the trees and between them was usually planted to some truck crop such as potatoes.

Roads. The public roads within this area totaled nearly six miles in their aggregate length. Most of these roads were narrow and were bordered by timber on one or both sides. Most of the roads were fenced off from the adjacent farm land. When the roads ran through or were bordered by timber the vegetation at their sides was practically the same as that of the timber-edge and the relation to birds was nearly the same in both. Parts of these roads were bordered by osage-orange which furnished favorable nesting sites and protection for several species of birds. Birds were frequently seen gathering food from the bare ground in the middle of the roads.

Pasture. The amount of land in permanent pasture in this area was less than that which was in cultivation. Most of the land in pasture was on slopes that were too steep for convenient cultivation. Other than a few scattered trees the chief vegetation was blue grass (*Poa pratensis*). The thickness of the cover which this grass made was dependent chiefly upon the amount of grazing which was permitted on it. Few birds were found in these pastures in winter. A few species nested and fed in the pastures in summer.

Cultivated Field. This part of the habitat was entirely artificial. Probably less than one-tenth of the ground not on the floodplain that was included in this area was in cultivation. The fields were small and were usually hilly. A larger portion of the land in the river bottom was cultivated because it was level there and was free from rocks. The chief crop on the floodplain was corn. On the upland corn and wheat were raised and some land was planted to hay crops such as clover, alfalfa, and timothy. Nearly all the birds that were found in the cultivated fields came there to feed. In summer there was an abundant supply of insect food on the ground, on the crop plants and on the weeds. In the winter there was usually a good supply of weed seeds in the fields, or around the edges of them.

Yard. The part of the habitat which is considered under this head is that small bit of ground which surrounds each group of farm buildings within this area. Around each house there are numerous large shade trees that are not too crowded to have large and well

developed crowns. These trees are of the same species as those found on the bluff and along the creek. The ground beneath the trees is usually bare. In winter and during the seasons of migration the birds which feed in the trees in the yards are the same small groups which move along the creek bottom and along the bluff.

The nesting population of the yards is much greater in proportion to the number of trees than it is in the surrounding woods. This popularity of farm yards for nesting purposes may be partly due to the presence of more suitable situations in the trees that are found there, but probably it is largely due to the greater protection which this nearness to man affords. Although a few new enemies such as the house cat are encountered, many natural enemies are escaped when birds select their nest sites near human dwellings. Of course this applies only to those species whose nest sites are in the yards.

Buildings. Four groups of farm buildings were found within the limits of this area as well as several scattered sheds and deserted buildings that stood alone. These houses and buildings furnished nesting sites for several species. There were two bridges across the creek and several smaller bridges within the area. These furnished some nesting sites.

Environmental Relations

Dangers. Man is a direct menace to the lives of a great many individuals of a few species of birds within this area. Most of the smaller species are not directly harmed by man here. With the game birds the situation is very different. Most of the land game birds have been hunted so much that, in the area studied, their numbers have been greatly reduced or they have become extinct. This point on the river is almost equally distant from both Saint Joseph, Missouri, and Atchison, Kansas, and is a favorite hunting ground for parties from both cities as well as for the residents of the surrounding country. Hunting on the lakes is much better than that on the river and, during the hunting season, ducks were shot on the lake nearly every day. It is very likely that the number of game birds killed in any one year within this area and during this study did not exceed five hundred.

A very few larger land birds were killed by farmers who thought that the birds were doing damage or who could not resist the temptation to kill any strange and conspicuous bird which they might see. The smaller birds were usually not harmed and most of those that were killed lost their lives by accidentally being trampled in nests or by some other unavoidable accident.

A few house cats were kept at farm houses in the area. In summer these animals depended to some extent upon the surrounding bird population for food for themselves and their broods of kittens. Young birds in the nests and near the ground in the immediate vicinity of houses, and others that had just left the nest, were the ones most often killed by cats. The large number of young cottontail rabbits that was available during the summer season made it possible for this animal to be substituted for young birds by the cats and so the losses to bird life were reduced. No increase could be noticed in the number of nesting birds near the houses in years when no cats were present.

Snakes, especially the pilot snake and the blue racer, were found to be important as natural enemies of birds during the nesting season. These snakes were able to climb the trees to reach the nests and as they were common they probably destroyed many nests of young birds or eggs during each summer season.

Other animals that were natural enemies of birds were chiefly a few species of predatory mammals and some raptorial birds. In the fall mink tracks were seen leading to and away from the remains of ducks, but the birds may have been cripples that would have died from the shock of their wounds. As raccoons took a few chickens from coops near houses and as they were common, they may have destroyed birds in the woods. A few skunks of the genera *Mephitis* and *Spilogale* were present and may have killed some birds although no actual instances were noted. Coyotes and foxes were present in such small numbers that they could not have killed many birds. Squirrels were present in considerable numbers and may have destroyed a few nests.

Several species of raptorial birds were present in sufficient numbers to provide an important check upon birds both in summer and in winter. These birds were not only serious dangers during the nesting season, but as they were able to capture small birds on the wing, they were feared at all seasons. Screech Owls were present during the whole year and in sufficient numbers to hunt over the whole territory. Short-eared Owls were found on the bar in winter and contents of pellets that they ejected showed that they had eaten Cardinals, Red-winged Blackbirds, and some small sparrows. Examination of these pellets indicated that less than one per cent of the food of this flock of owls during the time that it was present at this point consisted of birds. Other owls were found infrequently.

A few pairs of Cooper's Hawk nested in the timber and fed their young on chickens and probably other birds. Sharp-shinned Hawks were present in small numbers.

Figure 5. Dried mud at south side of Roundy Lake. Shore birds fed here before the mud dried as much as is shown in the photograph. Photograph taken September 24, 1922, by Dr. C. E. Johnson.

Figure 6. North part of Roundy Lake. Showing willow stumps in water in which Tree Swallows and Prothonotary Warblers nested. Photograph taken June, 1922.

No records of adult birds being killed by storms or bad weather were obtained during this study. High water from long continued and hard rains may have destroyed some nests that were placed too low. Strong winds destroyed some nests but most of them were rebuilt.

Examples were noted of a few dangers that are not included among those listed above. In late August when the woods were filled with spider webs of various sizes there was some danger of young birds becoming entangled in them. A Redstart was seen struggling to free itself from one of these webs on August 30, 1922. A gunshot nearby caused greater exertions and freedom for the bird. A crippled Virginia Rail which had probably hit a nearby telephone wire was found in a pasture on September 10, 1923.

Influence of Culture upon Birds

Favorable. The settlement and development of the land in this vicinity has benefited most birds in several ways. It has been accompanied by a decided increase in the variety and amount of food suitable for many species. The planting of cultivated crops has provided an abundant supply of grain which has been available for a short time between the time of ripening and the time of harvesting. Usually, there was left in the fields some waste grain which a few species of birds hunted out and ate. Insects have been introduced and have developed into a great variety of pests along with the planting and cultivation of crops. These are available for insect-eating birds. Many species of weeds have been introduced which have taken up every available bit of waste ground as well as the cultivated ground when special measures for their destruction have not been used. In addition to the insects for which these plants are hosts they furnish an abundant crop of seeds which is available through the winter for seed-eating birds. There has probably been an increase in the rodent population of this area proportionate to the amount of land that was put into cultivation. Greater numbers of these animals insured a much larger food supply for birds of prey.

Development of the land has made possible a greater variety of situations suitable for home sites for birds. This has made possible a greater variety in the species of birds which might nest in the vicinity and probably a greater number of individuals since a given bit of ground will support a larger population of birds usually if there are several species present than if only one or a few species live there. Clearing of land that was not immediately put into cultivation gave an opportunity for a new growth of sprouts and so gave new possibilities for nest sites. If the land were pastured blue grass

became the dominant plant and so another type of site was available for nesting. Orchard trees, shade trees, and planted trees along roads were spaced differently from those that grew naturally in the region and as a rule they had a different form from the native trees in their natural situations. Some species preferred these trees to the native trees for nest sites. Improvements such as bridges and buildings provide nest sites that are chosen by several species in preference to any that are found in the natural habitat. Making roads through the woods introduced more openings and tended to break down the climaxial character of the environment and by making it more complex made possible the presence of more species and individuals of birds.

The presence of man brought protection to some species of birds. Screech Owls often roosted in deserted buildings during the day. Juncos and other sparrows found excellent protection from the elements and from natural enemies by roosting in the tops of shocks of corn that were left in the fields. The same shocks were sometimes used in the daytime by resting Screech Owls. Human presence was also a benefit in that it caused the removal or decrease in numbers of some of the enemies of birds. Many raptorial birds were killed by hunters and farmers. Foxes, minks, bob-cats, and nearly all species of snakes were killed at every opportunity, so that their menace to bird life was greatly decreased. An increased interest in all birds, which most farmers in this vicinity have acquired, has led them to take special precautions in many instances for the protection and preservation of birds.

Unfavorable. Development of this region has in some ways been detrimental to the bird life of the vicinity. Mowing of hay lands while birds were nesting there has destroyed many nests with eggs or young. Cutting the timber, especially the larger trees of the bottomland, has removed some of the available nest sites of the larger species of birds so that they have gone to other localities to nest. Stock in pastures trample some nests.

The large amount of land that has been put into cultivation has affected the drainage so that most of the surface water runs off the ground rapidly after it falls, causing floods in the creek valleys and so destroying many nests that are placed near the ground. This change in the process or speed of drainage has tended to cause a restriction in the available supply of water for drinking especially during dry seasons when the creeks are nearly dry. This has had some effect upon the local distribution of some species in summer.

Destruction of some species of birds has been increased with human settlement in this area. Two important enemies (cat and dog) were brought in. They kill many birds. The destruction caused by these animals is greater than that of the same number of individuals of predatory animals that are native because the birds have developed no good means of escape from the imported ones. Men destroy many birds for sport and others because of an idea, sometimes mistaken, that they are harmful to agriculture in some way. An increased use of the roads by people in automobiles and the noise which the engines make as well as frequent picnic parties to the woods, the river and the lake frighten some of the more timid species away from the vicinity. Automobiles make hunting more destructive since this area is made more easily accessible by their use.

Influence of Birds upon Culture

Damage. A few pairs of nesting Cooper's Hawks fed their young chiefly upon small chickens which they took from farm yards in the neighborhood. English Sparrows damaged some of the vegetables that were grown in gardens by picking the young green leaves. The small amount of fruit that was grown on the farms within this area was damaged to a slight extent by birds. Catbirds were the chief fruit-eaters but they ate only a small part of the crop. Some small patches of grain that were sown near houses were damaged by English Sparrows which took nearly all the crop before it was harvested. Flocks of Bronzed Grackles in the fall damaged a few grain crops before they were harvested but they obtained only a small part of the grain.

Benefits. The game birds that were killed were used for food although they were hunted chiefly for sport and recreation. When this country was first settled the people were more dependent upon game for food than at present, but now the value of wild birds for food is very small in this vicinity.

Although most of the birds that were residents here fed upon insects or weed seeds, it was noted that in nearly every case the feeding range did not include the cultivated fields. Insect-eating birds fed chiefly upon insects that were found on the native vegetation. Birds that fed on weed seeds fed mostly on the waste ground where the growth of weeds was more dense and the available seed supply was greater than on the cultivated ground. Although these birds, each season, destroyed great quantities of weed seed, they apparently did not act as a check on the growth of weeds in the following season as every bit of available waste ground and all the fields, where

the weeds were not cut or plowed out, was filled with a dense growth of the weeds.

In the same way the birds of this area had little effect upon insect pests of the farm crops. Protective methods of cultivation were necessary to keep the fields and orchards free from insects as well as to keep them free from weeds.

The presence of the birds was necessary, possibly, to help keep in check the native species of plants and insects which without some such check might also have become injurious. The birds cannot be depended upon to keep down those introduced pests which must be contended with in every effort to cultivate plants. The fact that the stomach of a bird shows that it has eaten some injurious weed seed or harmful insect cannot be evidence that that species of bird is actually beneficial unless it is shown that the bird really reduced the damage which the pest was doing to the crop. Careful notes made in this area in the period of this study show that the weed seed-eating birds and insect-eating birds were of little value in destroying the actual pests of the crops that were cultivated. No attempt was made to determine to what extent these birds prevented native plants and insects from becoming serious pests to the crops. The situation is different in the timber. Very little of the timber is suitable for lumber and that which is used is chiefly used for firewood and fence-posts. Insect-eating birds which fed in the woods obtained their food directly from the trees and they probably were important as checks to prevent the increase of insect enemies of the trees.

Most of the Raptores were important as enemies of rodents although it is doubtful whether they had a great deal to do with the number of these rodents that were present. The increase and decrease in the numbers of the various species of rodents appeared to go on independently of their destruction by birds of prey. It was noted that when rabbits and field mice were most abundant, the number of hawks and owls present within the area was larger than when the number of rabbits and rodents was small. Since whole colonies of the rodents would suddenly disappear, it seems probable that their destruction was due to some other cause than that of being eaten by birds; in which case they would surely have decreased in numbers more gradually. It appears, then, that the number of rodents present has more influence in regulating the presence of predatory birds in this area than the number of the birds has in regulating the number of the mammals.

Response to Seasonal Change

Spring. With the beginning of spring weather, which is usually accompanied by the breaking of the ice on the river and the thawing of the ice on the creek and the lake, the early migrating ducks appear. Late in January Mallards and Pintails come. There is little change among the smaller land birds. Small groups of several species wander over several sections of territory on warm days. During cold waves they seek sheltered places and move very little. In February more of the water birds arrive. Herring Gulls, geese and Lesser Scaup Ducks were seen on the river. There are more warm days in this month and consequently there is more activity among the smaller species of birds. In March more species and larger flocks of ducks are found. The Pectoral Sandpiper, Greater Yellow-legs, and Killdeer are the wading birds that arrive in this month. Some of the winter visitant raptorial birds leave in March and other birds come from farther south. Belted Kingfishers become common. The first Phoebes that arrive in March are sometimes unable to find flying insects. Flocks of blackbirds begin to arrive during this month. Field Sparrows and Swamp Sparrows become common and the Ruby-crowned Kinglet arrives. There is some mating activity among the ducks on the lake and the Red-tailed Hawk and the Prairie Horned Lark begin to nest in this month.

During April and the first half of May, most of the summer residents arrive and begin nesting and the transients pass through on their way to the north.

Summer. During the first week in June a few straggling transients, chiefly crippled and aquatic birds, are still present around the lake. Most of the bird activity consists of caring for the young which, in the case of most summer residents, have hatched by this time in those nests which have met with no serious accident. Later in the month another nest is built by those species which nest a second time. Seventy-four species were found in July, nearly all of which nested within this area. Some species which nested there and were not common, were not found in July and a few that were found in July may not have nested within the limits of this area, but all of them probably nested within a few miles of there. On some of the hot days in July most of the birds were quiet and they were found in the shaded ravines where there were small pools of water. Larger birds, such as the Crow, were seen flying over on hot days with their mouths open on account of the heat. After the period of nesting most of the birds are hard to find for a few weeks while they are molting.

In some species the young and old birds gather in small flocks which range over a limited territory in search of food.

Fall. In early fall the bird population of this area is increased by a few species that reach this point by the first of August. The first to arrive are some of the Limicolae. Some species, as the Little Blue Heron, were found during their post-nest season wanderings. In the last part of this month several species of warblers arrive and are found for a few days feeding in the dense growth of vegetation. The largest number of species and individuals, for any fall period, is present in the first two weeks of September. Ducks are found on the lake from the last of August until the middle of November. Most of the insect-eating birds leave by the middle of October and for the next two weeks the smaller transients are chiefly the seed-eating Fringillidae.

Winter. The winter visitants to this area arrive in November and December and for a period in late December and early January there is a minimum of bird activity, when most of the birds present are flocks of seed-eaters which feed in the weed patches and the Raptores which feed on the small mammals. Thirty-four species of birds were found in December, the month with least activity.

Relationships between Species

The relations, that were noted between the species of birds that were recorded in this study, were largely food relations. Some of the birds of prey depended to a large extent upon their success in catching the smaller birds for a sufficient food supply. The sparrows and other small species that fed in thickets near the ground almost always flew hurriedly to thicker cover and became quiet whenever one of the smaller hawks appeared. Feeding shore-birds in flocks became nervous, called, and flew short distances when hawks flew near them. Pellets that were gathered from the roosting ground of a flock of short-eared owls contained remains of three species of small birds, but the number of individuals of birds eaten was very small in proportion to the whole amount of food, which was composed largely of rodents and shrews.

When any raptorial bird was discovered by Crows, the Crows began calling and flying around it and within a few minutes several hundred individuals, in some seasons, would be calling near the bird. If the bird moved the Crows would follow and continue their noise. If the bird remained quiet the Crows would soon tire of their excitement and would gradually scatter. These gatherings of Crows were

more often seen in winter than in summer as more and larger flocks of Crows were present in winter and there were more raptorial birds in winter.

Some discord was frequently noted between different species that nested near each other. Blue Jays chased Robins out of the former's nest tree. Wood Pewees drove intruding Blue Jays from the vicinity of their nests. Blue-gray Gnatcatchers and Ruby-throated Hummingbirds frequently were seen flying at some larger bird that was perched in or near the nest tree of the smaller one. In contrast to this, several instances were noted in two different species nested in the same tree. Blue Jays and Summer Tanagers nested at the same time in the same tree. Orchard Orioles and Yellow Warblers together nested in the same willow tree.

Usually when two or more species nested in the same kind of tree or in the same part of the habitat they chose different types of situations for their nests so that in most cases the kind of surroundings for the nest site was peculiar to each species. In some cases two closely related species chose nest sites that were similar in some ways but there were always some features that made each specifically distinct. For example, the Red-winged Blackbird and the Yellow-headed Blackbird nested in cattail and at about the same height but, within this area, the Yellow-headed Blackbird was limited to those patches of cattail which grew in water while the Red-winged Blackbird, in addition to that type of location, sometimes chose more dry situations and even nested in trees. This variation in the choice of a homesite made possible a much larger bird population since the supply of suitable nest sites would accommodate many more pairs than it would if they were more nearly alike in their choice.

On the feeding ground there was less necessity for insuring a permanent food supply as the adult bird could move to new grounds when the supply was exhausted at the old one. It is impossible for most species to move their nestlings so that some device is necessary to provide for the proper spaciation of the nesting pairs of birds. The capacity of each species to select a nest site of a type peculiar to it provides this device.

After the close of the nesting season, during the season of migration and in the winter groups of several species of birds were often found together and feeding. Sometimes, as in the case of those water birds which feed in flocks, most of the shore birds, the swallows which flew over the water and most of the smaller birds which fed in weed patches, the various species showed very little preference peculiar to

each one in selecting feeding grounds. For other species which gather food singly, as most of the Raptores, or which feed in groups which move through the timber where there are many types of feeding habitat, there is usually some choice in the particular part of the feeding ground which the individuals of each species occupy. The kinglets, creepers, titmice, woodpeckers, sparrows, warblers and wrens in a group of feeding birds each selected a part of the feeding ground peculiar to it and over which it fed without conflicting with birds of other species.

For roosting and for cover it is still less necessary that each species occupy a "niche" than for the other types of major activity. It was found that a particularly desirable thicket was used by many small species of birds as a refuge from enemies and as a roosting place.

It seems likely that in making any sort of study of the associations of birds it is necessary first to take into account the major activities of the species that are concerned. The knowledge of the mere presence of birds of two or more species in the same or a similar habitat is surely not significant in this connection unless the activity of each of those species in that habitat is known.

Succession

In every part of the habitat there was a constant change in the environmental conditions. These changes proceeded at different rates in the various divisions. Within this area the vegetation serves not only as an index to other environmental conditions, but for most of the nesting birds it appeared to be the most important factor in their presence or absence and in their local distribution.

Within the habitat area studied there are two kinds of habitat changes that are of major importance to the bird life of the vicinity. Each has a different cause and each has a different effect upon the birds. First, there are the natural changes, the most important of which are those which depend upon the erosive action of the Missouri River. When a change in the course of the river leaves a saucer lake such as Roundy Lake, a group of the birds which migrate up and down the river, but which do not regularly feed there, stops to feed in the more favorable lake waters. As soon as the aquatic vegetation has had a chance to develop in the lake to an amount sufficient to provide hiding places and nest sites, another group of birds is attracted which although present in smaller numbers, usually, than the first group, is present for a larger portion of the year. If the water of the lake is drained or is dried up too rapidly for a growth of vege-

tation and it leaves a broad belt of mud, still another group of birds is attracted to the ground to feed.

Sometimes the lake stage is omitted and in its place silt and sand are deposited to a level above the usual height of the water. When this happens or when the lake is gradually filled in so that the ground becomes dry, a dense cover of young and rapidly growing trees and other plants soon covers the ground. In their first seasons of growth these plants provide nesting sites for a few species of birds. If these plants are allowed to continue their growth the character of the vegetation is changed within three or four years so that the birds which nested there at first can no longer find suitable locations for their homes and so they are forced to live in another locality.

From this stage several factors control the development of the vegetation on the river floodplain in such a way that the growth goes on at different rates. Therefore a greater variety in available nest sites is produced so that a greater number of species and individuals remains to nest. If this land is allowed to remain in its place the development of the covering of plants continues. As the development proceeds the rate of change becomes slower until it is nearly imperceptible from one season to another. With some of the changes in the character of the vegetation some new species of birds are added to the list of possible residents and at the same time a few species that have nested there are eliminated because they can no longer find suitable home sites. For example, Crows and Warbling Vireos do not usually nest in the bottomlands until the cottonwoods have reached a certain size which requires about fifteen years of rapid growth. The Traill's Flycatcher does not nest after the willows have passed the thicket stage. Some other species, as the Yellow Warbler, nest in trees that are a little larger. In this way the nesting birds are added to or eliminated from the bird population. There is a gradual change in the group of nesting birds which corresponds to the change that takes place in the vegetation and which is caused chiefly by that change in the vegetation.

Natural changes or those changes which are set working by natural causes take place very slowly in other parts of this area so that only a very slight change is noticeable from year to year. The vegetation has reached a stage of climax on the bluff and in most of the creek bottom and so there is very little change in the bird life there that is due to naturally induced changes in the vegetation. A tree may die and furnish opportunity for hole nesting birds to make homes. Other trees are blown over and a small opening is made in

the timber. A new development of the cycle of plant growth on the bluff begins in these small places. In these clearings there is an opportunity for new species of birds to find home sites for a few years.

Predatory animals and other factors cause some changes in the bird life that can be noted when the effect of the changing vegetation has ceased to be the most important cause of succession in birds. These other factors are also at work in the other parts of the area but their effects are overshadowed by the greater effects of the plant changes.

The second great cause of avian succession in this area is the work of man. This work and its relation to birds has been discussed under the head of Relations to Culture. The works of man tend to cause an even greater irregularity in the succession than that which takes place under natural conditions and a more varied and therefore larger bird population can be supported on the ground than was possible under primitive conditions. With a greater utility of waste land and other resources, a point may finally be reached when the effect of man's work in this vicinity will be to eliminate nearly all the bird species.

At this time (1925) the area under discussion probably has a larger bird population than it had when it was entirely in primitive conditions. A few large and conspicuous species are extinct but many more are found now that were probably not present when the country was settled.

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